

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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COMMERCIAL AIRPLANES AND SEAPLANES.

By Etienne Royer.

From "Premier Congres International de
la Navigation Aerienne," Paris, November, 1921, Vol.II..

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To be returned to
the Chief of the Langley
Memorial Aeronautical
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Commercial Airplanes.

The ease with which commercial airplanes are operated when due to a well-marked route with special stations, makes it possible to give them quite large dimensions. Monoplanes with spans of 82.02 ft. to 98.4 ft. seem well suited to this purpose.

The thick wing should be exclusively employed. It should be very thick near the fuselage and in the vicinity of the engines, so as to include all projections capable of causing parasite resistance. It should taper gradually toward the ends, in order to eliminate useless weight. In a word, it should be of the Junkers type.

The great disadvantage of a "giant" monoplane is the excessive length of its fuselage, which makes landing difficult. The fuselage of a monoplane absorbs a large part of the fineness which this kind of airplane possesses in comparison with a biplane. In fact, for equal wing surfaces, the fineness is twice as great in a monoplane as in a biplane.

The length of the fuselage of a monoplane must be reduced nearly one-half, in order to give it the same maneuverability as that of a biplane. A triple advantage of reduction in weight, bulk and C_D (coefficient of drag) is also obtained.

Existing wing sections, unfortunately, do not make it possible to reduce the distance between the elevator and the center of

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gravity, on account of the instability produced by the shifting of the center of thrust.

In the near future, wing sections will be so designed, for the purpose of obtaining greater stability, as to cause the center of pressure to move further away from the leading edge of the wing, when the angle of attack or the speed is increased, and vice versa, and it will then be easy to reduce the size of the fuselage by means of these "auto-stable" wing sections.

The type recommended, therefore, for commercial use is the monoplane with very thick tapering auto-stable wings and short fuselage (about $1/3$ of the span).

The commercial airplane with large-carrying capacity should have special wings of the "Allula" type, with a very great C_L (coefficient of lift), so as not to exceed the practically realizable span of 83.02 ft. to 98.4 ft.

Commercial Seaplanes.

The difficulty of alighting on water, due to the waves, necessitates a minimum span and leads us to the multiplane.

The size of the fuselage must likewise be reduced in accord with the principles just laid down for monoplanes and with the remark of Mouillard: "Sea birds always have small tails." We can then dispense with the enormous "dolphin tails" which now handicap our seaplanes. It will be necessary to resort to auto-stable wing sections.

On account of the interaction of the wings, a triplane probably has the largest number that can be advantageously employed. The Dornier type of airplane with its small lower plane, seems well adapted. The monoplane, unless of small span, will remain a land airplane.

Thin Wings.

Since commercial airplanes and seaplanes are designed to have considerable carrying capacity and speed, it is necessary to consider the strength of the materials and to adopt the wing sections accordingly. The thin wing with a thickness of only 4 to 5% of the chord, as employed at the beginning of the war, can no longer be used, especially on monoplanes.

The thin wing, as recently improved (e.g. Göttingen wing section No. 442 of 6.6% thickness) can give, in a wind tunnel, results equivalent to those obtained with an excellent thick wing, but on a full-sized airplane the brace-wires appreciably diminish its efficiency.

The main advantages of the thin wing lie in its simple and economical construction (especially when made of wood) and in its consequent availability for experimental purposes.

When constructed on a large scale, for commercial airplanes, the aerodynamic superiority of the thick wings and their coefficient of safety will cause the abandonment of thin wings.

Bi-convex wing sections have given surprising results in the matter of fineness. Their small coefficient of lift unsuits them

however, for commercial aviation.

Thick Wings.

When the thickness of a wing exceeds 10% of its chord, it is called a "thick" wing; above 20%, a "very thick" wing. The thickness of a wing is very important from the aerodynamic point of view. At the present time, the thick wing of about 13% is considered superior to all others.

According to Prof. Prandtl's experiments on the product VL , some wing sections show a gain in C_L at large angles of attack, others a slight loss and still others remain stationary, while all wing sections show an improvement in C_D .

These two points need to be cleared up, in order to solve the problem and assign values not only to this class of wings but also to each particular wing section.

The test on the moving car is the indispensable complement of the tunnel test. If we do not have the results of the former test, we cannot accurately calculate the results for a regular airplane simply from the data of the tunnel test.

It is safe to say, however, that thick wings may have a fineness equal to that of the best thin wings. They also have the advantage of possessing a higher coefficient of lift, which makes possible a greater load per square meter. They also enable a greater range in the angles of attack and, lastly, since their maximum C_L is extremely high, they offer very great safety in landing and afford a higher "ceiling."

Tests on full-sized airplanes, as also on the "dynamometric car," enable the determination of the real properties of thick wings, properties which, thus far, the laboratory has alone disclosed.

Metal Construction.

In all airplanes undergoing tests and which have not been sufficiently improved, the "mixed construction" will be employed. When an airplane has stood its tests and is ready for quantity production, "metal construction" alone should be used.

Cases can be cited of new airplane cells, from a very large European factory, in which the spruce wing spars became unglued for a distance of more than 1.5 m. Wood can no longer be used in airplanes, but only metal and light alloys.

Many difficult problems still remain to be solved, in order to render all-metal construction practicable, namely: the kind of metal; manner of assembling and shape of parts for absorbing vibrations and effectively withstanding molecular changes and oxidation.

Some constructors make metal airplanes by stamping ribs out of thin sheet aluminum. It is conceived that the metamorphosis cannot easily take place without a transitional stage. This stage would render it possible to compare two airplanes of the same type and wing section: one of wood, the other of metal. Should the comparison be unfavorable to the metal airplane, it would be necessary to change the wing section and not the method

of construction, since the metal wing must be thick enough to absorb the vibrations entirely and be relatively very light.

Covering.

Cloth, where now used without support, can be definitely eliminated. Plywood, covered with cloth, would be preferable. Its weight per square meter is, however, rather high and it is affected by the weather.

Light metal is the only remaining material. For saving weight, it can be used in very thin open-work sheets, sufficiently thick (about 1 mm) to prevent distortion and to give shape to the wings. Thin sheets of light metal (only a few hundredths of a millimeter thick) can form the final covering. These can be secured to the frame by spot welding.

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